Combination of VLBI, GPS and SLR Software Development at FFI

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Abstract

FFI's contribution to the IVS as a Technology Development Center will focus primarily on the development and validation of the GEOSAT software for a combined analysis at the observation level of data from VLBI, GPS and SLR. This report briefly summarises the latest improvements of the GEOSAT software. FFI is currently Analysis Center for IVS and ILRS, Technology Development Center for IVS, and Combination Research Center for IERS.

1. The GEOSAT software

The advantages of the combination of independent and complementary space geodetic data at the observation level is discussed in Andersen ([1]). The models of GEOSAT are listed in Andersen ([2]). Recent changes are described in the following.

The GEOSAT software has recently extended the analysis capability from 30 to 60 GPS stations per day. In addition, a new procedure for the generation of a priori GPS orbits for the filter has been implemented. A three day IGS precise orbit for each GPS satellite is used as observations for the determination of a GEOSAT-generated GPS orbit. In this fit six orbital elements in addition to nine solar radiation pressure (SRP) parameters are solved for. The rms of residual fit for the three-day orbital dataset is typically between 2 and 4 cm for all satellites except for 2-4 satellites where the rms is significantly larger. The estimated orbit is used to generate a priori observation residuals and observation partial derivatives to be used in the filter where all data types are combined. In the 24 hour filter solution the nine-parameter SRP model are kept fixed and only the six orbital elements and one SRP-scaling parameter and a Y-bias parameter are solved for. In this way the one-day orbits will be based on a very realistic SRP model. However, for satellites with large rms of orbital fit two additional stochastic velocity change parameters are solved for. Experiments with the IGS precise orbits show that this parameterization is sufficient in order to fit a 24 hour GEOSAT-generated GPS orbit for all satellites including the outlier satellites with an rms of 2-3 cm in each coordinate. A significant part of the 2-3 cm difference is due to the use of inconsistent values for the EOPs. EOP values are taken from IERS and not the IGS EOP estimates to be used with the precise IGS orbits. In conclusion, a highly sophisticated GPS orbit strategy has been established. The use of a large number of GPS stations in combination with a moderate number of dynamical solve-for parameters and a realistic dynamical model is expected to result in GPS orbits with a precision level of a few cm in each coordinate.

It is a fact that the position of the effective phase center of the transmitter antenna of the GPS satellites is not very well known. This leads to a scale inconsistency with VLBI and SLR of approximately 2 ppb. It is therefore a standard procedure in analysis with GEOSAT to estimate the z-coordinate of the mean position of the transmitter phase center. With GPS-data alone it is only possible to determine the phase center position relative to the position of the phase center of a reference satellite. Since the GPS data in our case are combined with VLBI and SLR data absolute positions of the phase center of all satellites can be determined.

Another possible candidate for scale inconsistency between the different techniques is the tropospheric mapping function. In order to be consistent with VLBI and GPS the SLR data are analyzed with the use of the dry NMF mapping function which is used for VLBI and GPS. The signal delay in the zenith direction is however calculated using the Marini-Murray model. This procedure is in accordance with recent recommendations given by Richard Eanes. A model for tidal geocenter motion is implemented (Watkins and Eanes, [3]).

In GEOSAT data from the different techniques are combined in batches of one day which is called an arc. The state vectors and complete variance-covariance matrices from the analyses of a number of independent arcs of space geodetic data can be combined using the CSRIFS (Combined Square Root Information Filter and Smoother) program. Four parameter levels are available and any parameter can, at each level, either be represented as a constant or a stochastic parameter (white noise, colored noise, or random walk). The batch length (i.e. the time interval between the addition of noise to the SRIF array) can be made time- and parameter dependent. More details can be found in Andersen ([1]).

2. Prospects

Two new programs in the GEOSAT system are under development. The IERS program will transform the output from internal reference frames in GEOSAT to the external reference frames of the IERS. Also the final combined covariance matrix of CSRIFS will be rotated. The SINEX program will write the global solution in the SINEX format.

Statens kartverk has recently received a copy of the GEOSAT software.

The GEOSAT software will be converted to PC/LINUX in the near future.

3. Technical Staff

Table 1 lists the FFI staff involved in IVS activities.

Table 1. Staff working at the FFI AC and TDC

Name	Background	Dedication	Agency
Per Helge Andersen	geodesy	40%	FFI

References

[1] Andersen, P. H. Multi-level arc combination with stochastic parameters. Journal of Geodesy (2000) 74: 531-551.

[2] Andersen, P. H. High-precision station positioning and satellite orbit determination. PhD Thesis, NDRE/Publication 95/01094.

[3] Watkins M., Eanes R. Observations of tidally coherent diurnal and semidiurnal variations in the geocenter. Geophysical Research Letters, Vol. 24, No. 17, 2231-2234, Sep 1, 1997.